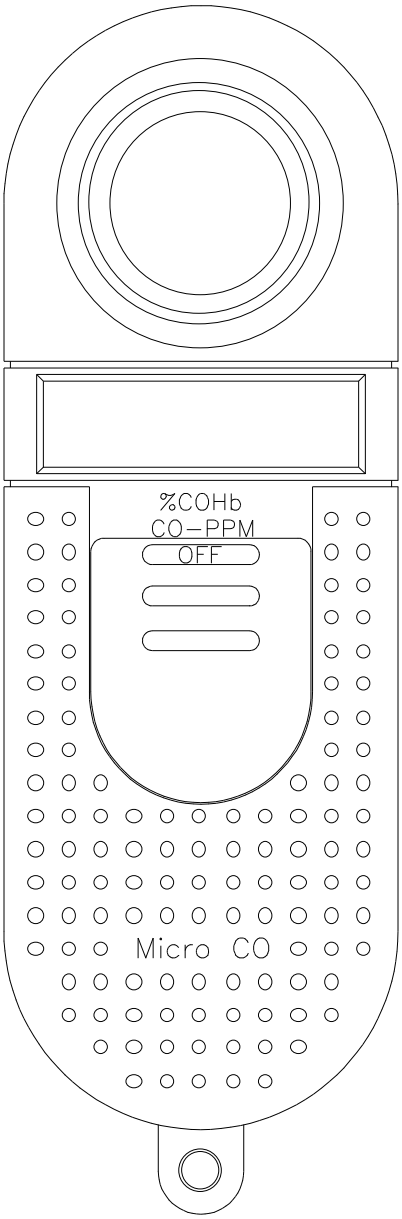


Contents page

Safety Precaution	**2**
Important safeguards	**2**
Looking after your Micro CO meter	**2**
Introduction	**2**
Before you begin	**2**
Micro CO meter system Overview	**3**
CO sensor	**5**
Micro CO meter exploded view	**6**
Disassembling the Micro CO meter for Servicing	**7**
Replacing the service parts of the Micro CO	**7**
Reassembling the Micro CO meter	**8**
Calibrating the Micro CO meter	**9**
Circuit description	**10**
Specifications	**13**
Technical support	**14**
Parts List	**15**
Circuit Diagram	**17**

Micro CO Meter Service Manual

037-16 Iss. 1.2 September 1998

[redacted]

Micro CO Meter

Service Manual

Information in this document is subject to change without notice and does not represent a commitment on the part of Micro Medical Limited. Only the parts supplied by Micro Medical Limited should be used to complete the service operation described in this manual. If in any way you feel unsure about the successful completion of the service operation you should contact Micro Medical Limited or its appointed agent in your country or region and arrange the despatch of the product to a Micro Medical Limited Service Centre.

Copyright 1998 by Micro Medical Limited All rights reserved

Drawing no. 037-16

Version 1.2

September 1998

All other products are trademarks or registered trademarks of their respective owners.

Safety Precaution

The servicing of this device is intended to be carried out by a properly trained and competent electronics engineer, or experienced in the maintenance and servicing of medical devices. Read this manual thoroughly before proceeding with the service. If in any doubt please contact the service centre at Micro Medical Limited or their accredited agent in your country or region.

Important Safeguards

- Read all of the instructions.
- Keep the instructions in a safe place for later use.
- Follow all warnings and instructions marked on the product.
- When replacement parts are required, be sure to use replacement parts specified by Micro Medical that have the same characteristics as the original parts. Unauthorised substitutions may result in fire, electric or other hazards.
- Do not place on an unstable table.
- The product should be operated only from the type of power source indicated on the label.

Looking after your Micro CO Meter

- Avoid exposing the Micro CO Meter to direct sunlight.
- Avoid operating the Micro CO Meter in dusty conditions or near to heating appliances or radiators.
- Do not keep the Micro CO Meter in a damp place or expose it to extreme temperatures.

Introduction

This service manual provides you with information to carry out the servicing of the Micro CO Meter. It is a process, which is relatively straightforward but must be carried out in a logical sequence. Our advice is to familiarise yourself with the contents of this manual before attempting to carry out the procedure of replacing the parts supplied in the sensor replacement kit for the Micro CO Meter.

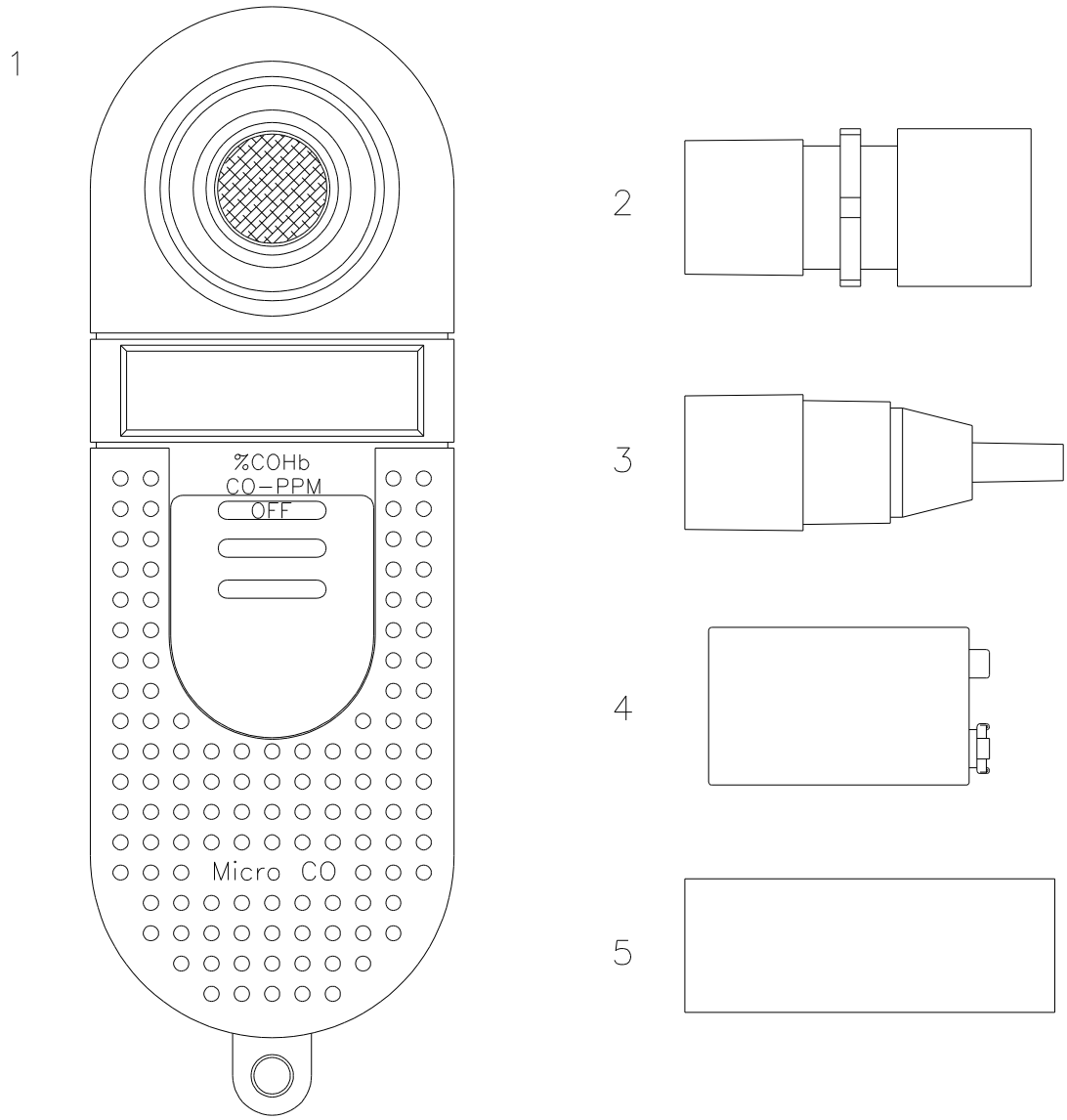
Before You Begin

Before you begin the servicing operation, please read the section on Circuit description very carefully:

Micro CO Meter system overview.

The Micro Medical Micro CO meter consists of a hand held microcomputer unit (1) incorporating a CO sensor and is supplied with a mouthpiece adapter with integral one way valve (2) together with disposable cardboard mouthpieces (5).

The microcomputer unit is powered by a single alkaline PP3 battery (4) and is supplied with a reducing connector for calibration (3).



The CO sensor is an electrochemical fuel cell, and works through the reaction of carbon monoxide at one electrode and oxygen (from ambient air) at the other. This reaction generates an electrical current proportional to the concentration of CO exposed to the sensing surface of the fuel cell.

The current output signal from the sensor is conditioned using a current to voltage converter and is applied to an analogue to digital (A/D) converter inputs of the microprocessor.

When the unit is first switched on the microprocessor records the baseline reading on the A/D input and uses this value to auto zero the instrument.

The subject is requested to breathe in maximally, hold the breath for 20 seconds, and then to expire fully through the mouthpiece connected to the microcomputer unit with the mouthpiece adapter.

The microprocessor then records the peak value obtained and displays this on a 3½ digit LCD display.

The value can be displayed either as parts per million (ppm) concentration in the expired air or as the equivalent percentage carboxyhaemoglobin (%COHb) using the mathematical relationships described by Jarvis et al, for concentrations below 90ppm and by Stewart et al for higher concentrations.

Jarvis MJ, Belcher M, Vesey C, Hutchison DCS

Low cost carbon monoxide monitors in smoking assessment.

Thorax 1986; 41:886-887

Stewart RD, Stewart RS, Stamm W, Seleen RP

Rapid estimation of carboxyhaemoglobin levels in fire fighters

JAMA 1976; 235:390-392

CO Sensor

The sensor is an electrochemical micro fuel cell using gaseous diffusion barrier technology resulting in a direct response to volume concentration rather than partial pressure as with other fuel cells.

The fuel cell uses a three electrode design which gives increased selectivity to the measured gas compared with two electrode designs. The three electrode cell consists of a sensing electrode, a counter electrode and a reference electrode separated by a thin layer of electrolyte. The gaseous diffusion barrier limits the flow of gas to the sensing electrode and ensures the electrochemical activity of the electrode is far in excess of the amount of gas with which it has to deal.

Gas diffusing onto the sensing electrode reacts at the surface of the electrode by oxidation.

CO reacts at the sensing electrode according to the equation:

$$CO + H_2O \rightarrow CO_2 + 2H^+ + 2e^-$$

The counter electrode acts to balance out the reaction at the sensing electrode by reducing oxygen in air to water:

$$\tfrac{1}{2}O_2 + 2H^+ + 2e^- \rightarrow 2\,H_2O$$

The CO fuel cell requires a bias voltage of 220mV to be supplied permanently to the reference electrode.

The low power circuitry supplying this voltage, is powered by an internal, 950mA –hr lithium cell with an operational life greater than the life of the electrochemical fuel cell.

Micro CO meter exploded view

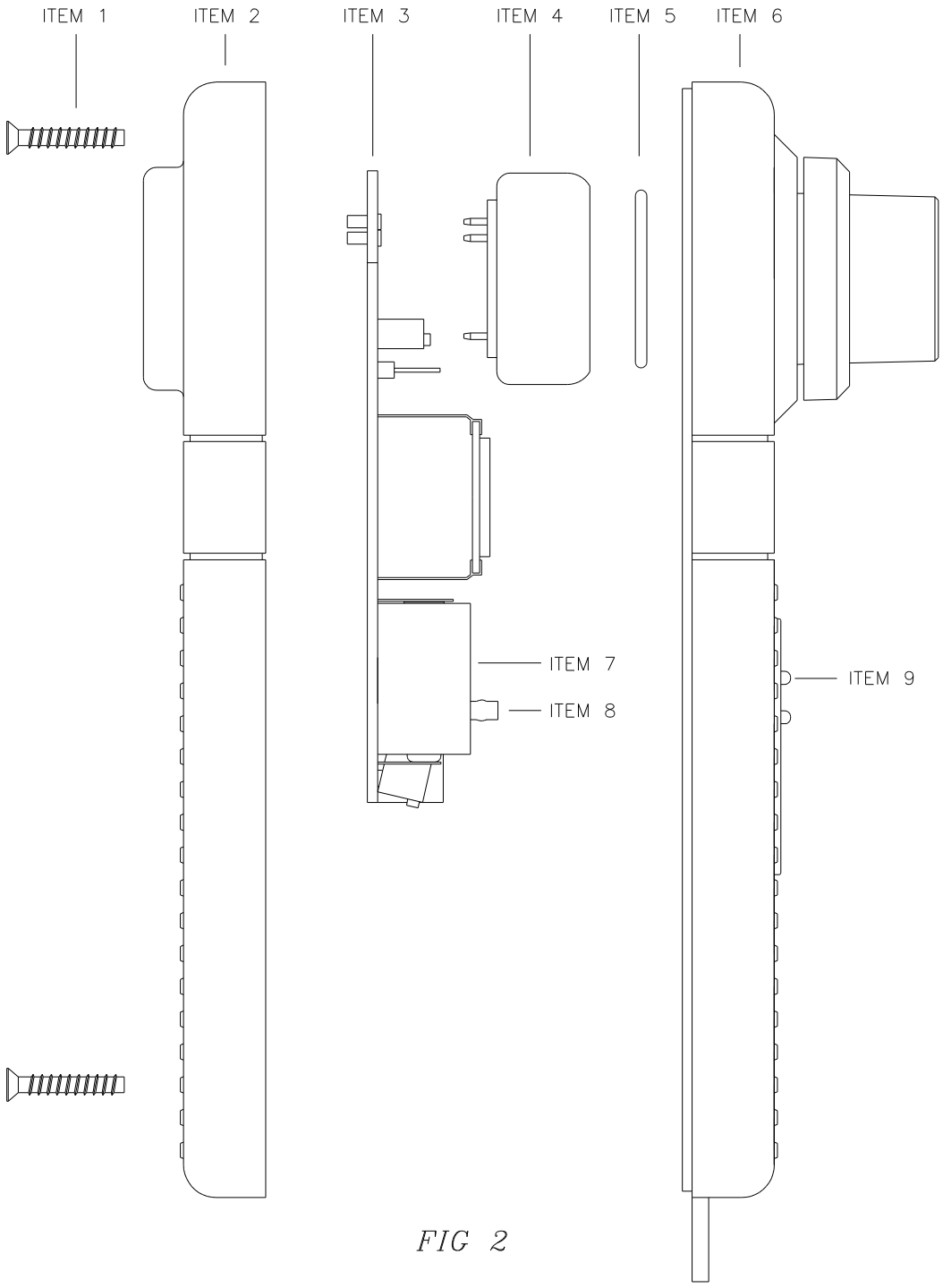


FIG 2

Disassembling the Micro CO meter for servicing.

The Micro CO microcontroller unit comprises of a solid state electronic circuit in a robust ABS housing and does not require any preventative maintenance.

Routine maintenance consists of replacing the fuel cell and internal lithium battery when they are exhausted. The 3.6 volt lithium battery is continuously monitored by the microcontroller and the message **CEL** will be displayed when the voltage falls below 3 volts. When this happens replace both the fuel cell and the lithium battery by following the procedure below.

1. Turn the unit face down and slide back the battery compartment.
2. Remove the PP3 battery.
3. Remove the 2 self tapping screws (Item 1) and put to one side.
4. Lift the top moulding (Item 6) from the bottom moulding (Item 2).
5. Remove the PCB (Item 3) from the bottom moulding.
6. Carefully remove the fuel cell (Item 4) and disregard.
7. Unsolder the lithium battery (Item 7) from the PCB and disregard.

Replacing Service parts of the Micro CO.

1 Solder the new battery in place (Cat No: BAT3700) **(Take great care not to short circuit the terminations even momentarily as the low internal impedance of lithium batteries will result in a high current consumption and greatly reduced life).**

2 Remove the CO (Cat No: MCEL3700) sensor from the plastic container.

3 Remove the wire shorting link from the reference and shorting pins and carefully insert the CO cell into the PCB. **(Note: The fuel cell must not be left for more than a few minutes without the shorting link before inserting into the PCB or damage to the cell may result).**

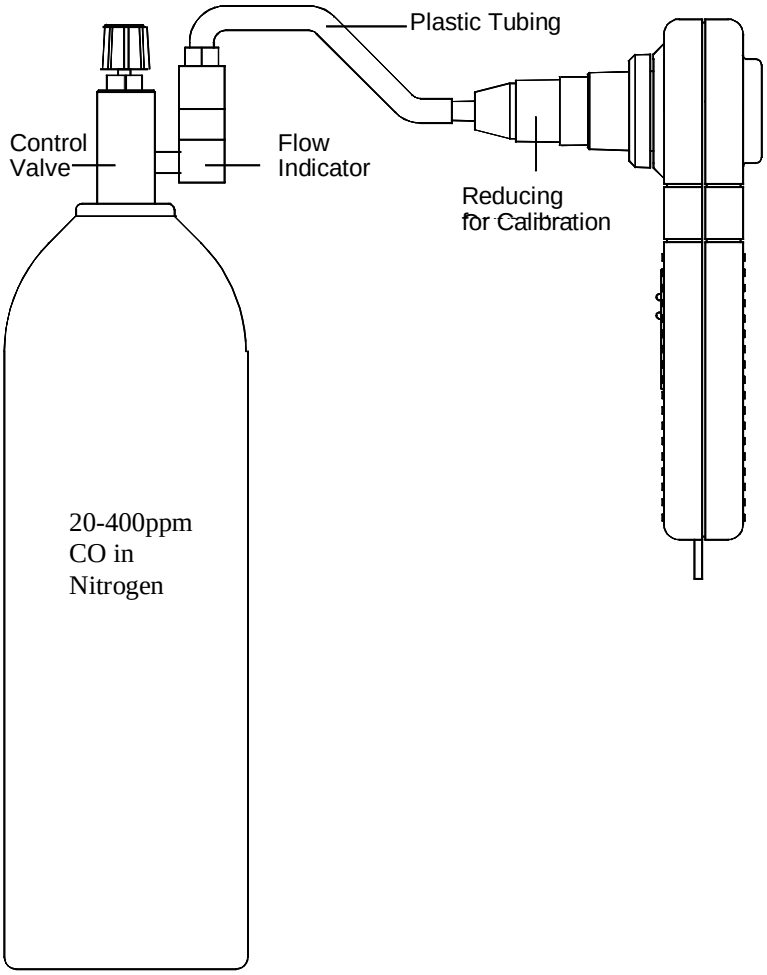
4 The assembled PCB must now be left for two weeks to allow the fuel cell to stabilise at the bias voltage of 220mV.

5 After two weeks check that the output of the op-amp (IC3D) is between 180 and 220mV with the unit switched on and no carbon monoxide present on the sensor (This can be measured between the two test points adjacent to the slide switch. If necessary adjust VR1 to bring the voltage within range.)

Reassembling the Micro CO meter

1. Place the PCB into the bottom moulding.
2. Ensure that the slide switch (Item 8) and the switch plate (Item 9) are both positioned at the bottom of their travel.
3. Ensure that the O.ring (Item 5) supplied with the fuel cell is in place.
4. Place the top moulding on top of the bottom moulding and secure using the two self tapping screws.
5. Reconnect the PP3 battery ensuring correct polarity.

Calibrating the CO meter



1. Setup the calibration equipment as shown above.
2. Locate the calibration potentiometer positioned in the battery compartment by moving the battery without disconnection.
3. Slide the switch on the Micro CO meter to the middle position (CO-PPM)
4. Supply a flow of CO in Nitrogen at a rate of approximately 4 l/min for 25 seconds and then turn off the supply.
5. Wait until the reading on the LCD display has stabilised.
6. Adjust the potentiometer so that the reading on the LCD display is the same as the measured reading on the gas bottle.
7. The unit is now ready for operation.

Circuit description

(Refer to parts list , and to circuit diagram 037-20)
The circuit is based on the Motorola one time programmable (OTP) microcontroller MC68HC705C9ACP (IC1) operating at a clock frequency of 1 MHz.
This processor contains 7 Kbytes of EPROM, 176 Bytes of RAM, programmable output latches, and a serial peripheral interface (SPI). The current output signal from the sensor is conditioned using a current to voltage converter and is applied to a 8 channel analogue to digital (A/D) converter connected to a microprocessor. The calibration potentiometer is also connected to the A/D converter.
When the unit is first switched on the microprocessor records the baseline reading from the A/D and uses this value to auto-zero the instrument. The signal from the CO sensor and the voltage from the calibration potentiometer are both continuously monitored and the peak of the calculated carbon monoxide concentration is displayed.

Power Supply

The unit has two separate supplies. The main supply is provided by the externally accessible alkaline 9 volt PP3 battery (BAT 1). The instrument may be switched on and off with the slide switch and may also be switched off by a signal from the processor. This is done if the unit is left on, without use, for a period of 5 minutes in order to conserve battery power. The supply is controlled by gates A and B of IC2, arranged in a bi-stable configuration, and powered continuously from BAT1. When the slide switch is moved to the 'CO-PPM' position one end of R23 is pulled low. This transition is differentiated by the action of C12 and R22 so that a momentary pulse appears on pin 9 of IC3. This pulse will toggle the bi-stable circuit so that pin 11 will go low, turning transistor TR3 on, and supplying 9 volts to the low drop-out regulator, IC4. When the slide switch is returned to the 'off' position pin 13 of IC3 is pulled low, the bi-stable action is reversed, and TR4 will be turned off. If the unit is left on without use for 6 minutes then pin 30 of IC1 is driven high, under software control, turning on TR1 which will also turn the unit off via the bi-stable circuit. When this happens the slide switch must be pushed to the 'off' and then to the 'CO-PPM' position in order to initiate another pulse through C12 to turn the unit back on again. The output of the 5 volt regulator supplies the processor and associated circuitry. The input and output of IC4 is smoothed by C1 and C2 respectively.
The secondary power supply is provided by a single 3.6 volt lithium cell used to permanently power the fuel cell conditioning circuit consisting of the op-amps (IC5 and IC6), and the precision voltage reference (ZD1) together with the associated passive circuitry. The conditioning circuit draws less than 72uA from the 950 mA-Hr lithium battery giving an operational life of 18 months.

Fuel cell conditioning circuit

For correct operation the reference electrode of the fuel cell must be held at a constant bias voltage with respect to the sensing electrode (-220mV). This is achieved by applying a voltage to the counter electrode to induce the correct bias voltage.

The 3.6 volt supply from BAT2 is split by the action of R17 and the low power reference diode (ZD1) to give a 2.34/-1.26 volt supply with the anode of ZD1 connected to 0 volts.

The stable –220mV reference is, generated by the potential divider formed by R18 and R19. This reference is applied to the non-inverting input of IC5. The output of IC5 is applied to the counter electrode through R1. The inverting input of IC5 is connected to the reference electrode through R2 and R3.

The negative feedback of this circuit ensures that the counter electrode is held at whatever potential is required (nominally –350mV) to keep the reference electrode at –220mV with respect to the sensing electrode.

The sensing electrode is held at 0 volts by the action of R5 and R6 which, is connected to the virtual earth point of IC6.

Fuel cell amplifier circuit.

The fuel cell provides an output current, from the sensing electrode, proportional to the concentration of target gas at the sensing surface. This current is converted to a voltage by the action of IC6 and the associated passive components at a transfer factor of 15mV/µA. This signal is further amplified by IC3 (b) and applied to IC8. The sensitivity of the CO fuel cell is 0.1 +/- 0.02µA giving a nominal output of 1.5mV/ppm CO. The output of IC6 is filtered at 60Hz by R9 and C11 and applied to the input of IC3(B).

A/D converter

The A/D converter is a 10 bit, 8 channel, serial interface, low powered device with an integral voltage reference of 4.096 volts.

Channel 0 is used to monitor the output of the fuel cell.

Channel 1 monitors the lithium battery (BAT2) from the output of the buffer amplifier IC3(A). R16, between BAT2 and the inverting amplifier, prevents the battery from discharging through the op-amp when the supply is switched off. The battery has an end point of 3 volts and when this level is reached the message CELL will be displayed. When this happens follow the procedure outlined in **Servicing**.

Channel 2 measures the setting on the calibration potentiometer (VR2) which can be adjusted between 0 volts and Vref.

Channel 3 is used to monitor the PP3 battery (BAT1) through the potential divider, R13 and R14. When this battery falls below 6.6 volts a battery low warning is temporarily indicated on the display upon switch on. When the battery falls below 6.1 volts the message is displayed permanently and the unit cannot be used.

Reset Circuit

This consists of the dedicated reset controller IC7. This device holds the reset low whilst the supply voltage is below 4.5 volts and takes the reset high after a period of 350msec once the supply has stabilised.

Display

The display is a custom 3½ digit low power LCD. The seven segments of the three digits, the decimal point, the backplane and the blow legend are driven directly by ports A,B and C of the microprocessor. The backplane is driven by a square wave of nominally 60Hz. The individual segments are driven by a similar square wave which is in phase with the backplane when the segment is off and 180 degrees out of phase when the segment is on.

Sounder

The sounder is operated by a 1kHz square wave generated by pin 35 of IC1. One connection of the sounder is driven directly by pin 35 and the other by the inverted signal from TR1. This push-pull arrangement raises the driving voltage to the sounder and increases the volume

Specifications

Type	Micro fuel cell
Range	0 – 500ppm
Resolution	1ppm
Sensor Life	>1 year
Response time	<20 sec (to 90% of reading)
Hydrogen cross sensitivity	<10%
Operating temperature	0 to 40°C
Operating pressure	Atmospheric +/-10%
Pressure coefficient	0.02% signal per mBar
Relative humidity	15 – 90% continuous
(Non condensing)	(0 – 99% intermittent)
Baseline drift	0ppm (auto zero)
Long term drift	<2% signal loss per month
Power source	Single Alkaline 9 volt PP3
Battery life	>30 hours of continuous use
Weight	160g
Dimensions	170 x 60 x 26mm
Display	3½ digit LCD

Technical Support

Great Britain and World Headquarters

Micro Medical Ltd

PO Box 6

Rochester

Kent ME1 2AZ

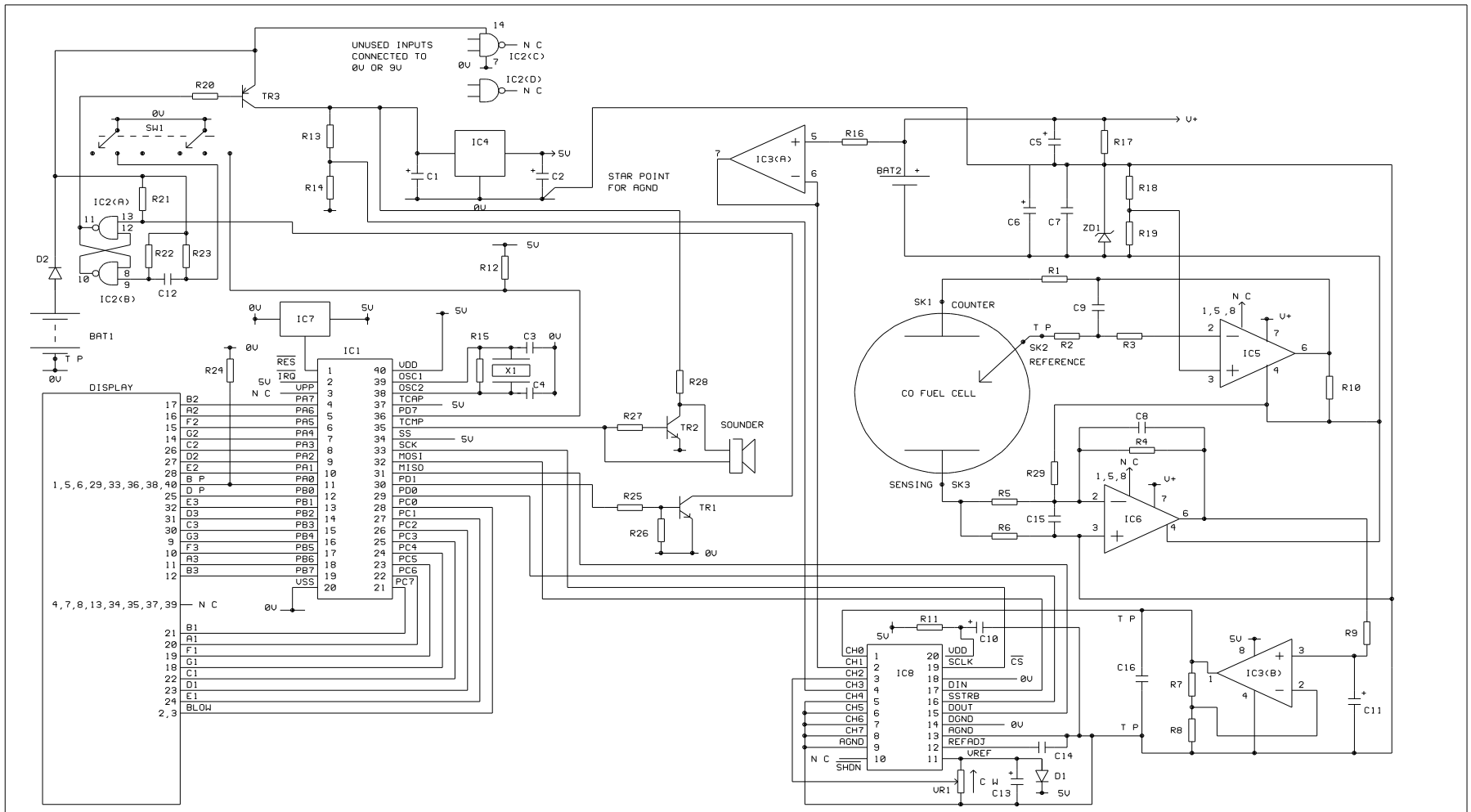
Telephone	+ 44 (0)1634 360044
Fax	+44 (0)1634 360055
Web Site	http://www.micromedical.com.uk
Email	support@micromedical.com.uk

Contact Micro Medical Ltd for the local agent in your region or country for local service:

Parts List

Designation	Description
IC1	**(MC68HC705C9ACP)** MOTOROLA OTP MICROCONTROLLER
IC2	**(4093)** QUAD 2 INPUT NAND GATE
IC3	**(TL27L2CP)** DUAL LOW POWER OP-AMP
IC4	**(LM2931AZ5)** LOW DROP OUT LOW POWER 5 VOLT REGULATOR
IC5	**(OP90GS)** PRECISION MICRO POWER OP-AMP
IC6	**OP90GS)** PRECISION MICRO POWER OP-AMP
IC7	**(DS1233-10)** DALLAS ECONO RESET
IC8	**(MAX186DCAP)** 12 BIT SSOP SERIAL D/A OR **(MAX192BCAP)** 10 BIT A/D
D1	**(1N4148)** GENERAL PURPOSE DIODE
D2	**(BAT42)** GENERAL PURPOSE SCHOTTKY DIODE
ZD1	**(TC04BCZM)** 1.26V BANDGAP REFERENCE
DISPLAY	**(LCD 016-03)** 3½ DIGIT CUSTOM DISPLAY
TR1	**(BC182LB)** NPN TRANSISTOR TO92(A) PACKAGE ALTERNATIVE **(BC182LC)**
TR2	**BC182LB)** NPN TRANSISTOR TO92(A) PACKAGE ALTERNATIVE **(BC182LC**
TR3	**(ZTX751)** PNP TRANSISTOR E-LINE PACKAGE
R1	1K SURFACE MOUNT RESISTOR 0.125 WATT 5% SIZE 1206
R2	10K SURFACE MOUNT RESISTOR 0.125 WATT 5% SIZE 1206
R3	10K SURFACE MOUNT RESISTOR 0.125 WATT 5% SIZE 1206
R4	15K SURFACE MOUNT RESISTOR 0.125 WATT 5% SIZE 1206
R5	10 OHM SURFACE MOUNT RESISTOR 0.125 WATT 5% SIZE 1206
R6	1K SURFACE MOUNT RESISTOR 0.125 WATT 5% SIZE 1206
R7	10K ¼WATT 5% RESISTOR
R8	3.3K ¼WATT 5% RESISTOR
R9	22K ¼WATT 5% RESISTOR
R10	100K SURFACE MOUNT RESISTOR 0.125 WATT 5% SIZE 1206
R11	10 OHM ¼WATT 5% RESISTOR
R12	4.7M ¼WATT 5% RESISTOR
R13	100K ¼WATT 5% RESISTOR
R14	100K ¼WATT 5% RESISTOR
R15	100K ¼WATT 5% RESISTOR
R16	1M SURFACE MOUNT RESISTOR 0.125 WATT 5% SIZE 1206
R17	100K SURFACE MOUNT RESISTOR 0.125 WATT 5% SIZE 1206
R18	180K SURFACE MOUNT RESISTOR 0.125 WATT 5% SIZE 1206
R19	820K SURFACE MOUNT RESISTOR 0.125 WATT 5% SIZE 1206
R20	10K ¼WATT 5% RESISTOR
R21	1MEG ¼WATT 5% RESISTOR
R22	1MEG ¼WATT 5% RESISTOR
R23	1MEG ¼WATT 5% RESISTOR
R24	100K ¼WATT 5% RESISTOR
R25	10K ¼WATT 5% RESISTOR
R26	10K ¼WATT 5% RESISTOR
R27	10K ¼WATT 5% RESISTOR
R28	10K ¼WATT 5% RESISTOR
R29	1.8MEG SURFACE MOUNT RESISTOR 0.125 WATT 5% SIZE 1206
VR1	**(3266X-100K)** 100K MULTI TURN POTENTIOMETER
C1	47µF 16 VOLT ELECTROLYTIC CAPACITOR
C2	47µF 16 VOLT ELECTROLYTIC CAPACITOR
C3	47pF CERAMIC CAPACITOR
C4	47pF CERAMIC CAPACITOR
C5	47µF 16 VOLT ELECTROLYTIC CAPACITOR
C6	47µF 16 VOLT ELECTROLYTIC CAPACITOR
C7	0.1µF CERAMIC CAPACITOR

C8	1µF MULTILAYER CERAMIC CAPACITOR
C9	0.1µF CERAMIC CAPACITOR
C10	47µF 16 VOLT ELECTROLYTIC CAPACITOR
C11	47µF 16 VOLT ELECTROLYTIC CAPACITOR
C12	0.1µF CERAMIC CAPACITOR
C13	47µF 16 VOLT ELECTROLYTIC CAPACITOR
C14	0.1µF CERAMIC CAPACITOR
C15	100pF CERAMIC CAPACITOR
C16	1nF CERAMIC CAPACITOR
SW1	**(SLF2300)** DOUBL POLE 3 POSITION SLIDE SWITCH
BAT2	**(LS14250)** SAFT PCB MOUNTED 950mA-HOUR LITHIUM CELL
X1	4MHz CERAMIC RESONATOR



DRAWN	TITLE	ISSUE	DATE	DESCRIPTION OF MOD	DATE	DESCRIPTION OF MOD
C P L	MICRO CO METER	1 3				
DATE 15/9/98	DRAWING No 037-20					